Assessment of MATH Skills in Different Populations of Students: BIOL 190, BIOL 251 and CHEM 121

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Abstract/Executive Summary

A prospective meta-analysis examining MATH skills in students enrolled in BIOL 190 1003/1004, BIOL 251 1003/1004 and CHEM 121 1001/1002 during Fall 2019 was obtained. CHEM 121 students surpassed both BIOL 190 and 251 students over the same content and identical time between pre-test and post-test. Averages for BIOL 190 and BIOL 251 students were less than the CHEM 121 students' post-test average score (BIOL 190 $p <<< 0.001$; BIOL 251 $p < 0.001$). CHEM 121 students are statistically more mathematically inclined ($p <<< 0.001$) than BIOL 190 and 251 students. There is non-congruency between students' self-reported final MATH course grades and their results from the MATH Primer Assessment. The courses for which demographic information was obtained fill two niches at WNC: the younger student (CHEM 121) and the more mature, returning, student (BIOL 190). It remains highly recommended that the minimum MATH pre-requisite for BIOL 190 be changed as previously proposed.

147 words; Flesch-Kincaid 15.8

Introduction

In a previous assessment report [1], it was suggested "*that CHEM students might be more "numbers" oriented than the BIOL students*". At that time a retrospective meta-analysis was explored that provided data that was clear that MATH 126 was a far superior minimum MATH pre-requisite for both CHEM 121 and BIOL 190 than lower-level courses [Ibid, p. 7 of 23, Table 1]. Recommendations to adjust the MATH pre-req statements to BIOL 190 (and CHEM 121) were submitted in March 2019; they have not been implemented at this time.

At the time of the writing of the previously cited report, however, no formal assessment was fully developed to explore the reviewing and/or [re-]learning of fundamental MATH concepts applicable to both BIOL and CHEM students post-MATH pre-requisite course and pre-BIOL 190/CHEM 121 review [2].

MATH review topics in the MATH Primer [Ibid] span High School Algebra, Geometry and Trigonometry common to courses taught to high school students in the 1970's. In addition, topics from the old WNC MATH 100B, Math for Nurses, taught by the author in academic year 2002-2003 for Surgical Technology students are included as they provide exemplary examples of dimensional analysis and are clearly preparatory for students seeking admittance into any Nursing Program in the NSHE (or the country, for that matter), as well as those seeking degrees that require dimensional analysis skills to solve problems in related biophysical science fields. Furthermore, many of the topics in the MATH Primer are covered in MATH 096 and MATH 126 (and 127, which is required pre-CHEM 122) at WNC (cf **Appendix 1** for clarifying statements regarding WNC MATH courses and Openstax content (Personal Communication, Sep 5, 2019 at 12:04 PM Dr. Gary Schwartz)).

It is through the completion of the MATH Primer in Fall 2019 that this prospective meta-analysis examining MATH skills in students enrolled in BIOL 190 1003/1004, BIOL 251 1003/1004 and CHEM 121 1001/1002 was obtained.

Materials and Methods

A pre-test/post-test method was chosen, using the same question inclusion/exclusion criteria as previously reported upon [3].

The pre-test was administered on the first day of class using iPads checked out from the WNC Division of Innovation and Learning.

In all cases, the post-test was administered under the same conditions: iPads and exactly 15 days after the first day of class.

In the cases of BIOL 190 and 251, no pre-test was administered and is indicated by “post-test”; however, in CHEM 121 both pre-test and post-test were administered.

Standard High, Average, Standard Deviation and Low scores were determined using an Excel spreadsheet.

Students’ two-tailed t-test for significance was used to determine any statistically significant differences; the minimal p value for significance was set at < 0.05.

Results

As can be seen in **Figure 1**, below, when comparing pre-test and post-test (and “post-test” in the case of BIOL 190 and 251) averages, the CHEM 121 students surpassed both BIOL 190 and 251 students over the same content and identical time between pre-test and post-test. “Post-test” averages for BIOL 190 and BIOL 251 students, while in excess of the CHEM 121 students’ pre-test averages, nevertheless were less than the CHEM 121 students’ post-test average score (BIOL 190 p <<< 0.001; BIOL 251 p < 0.001).

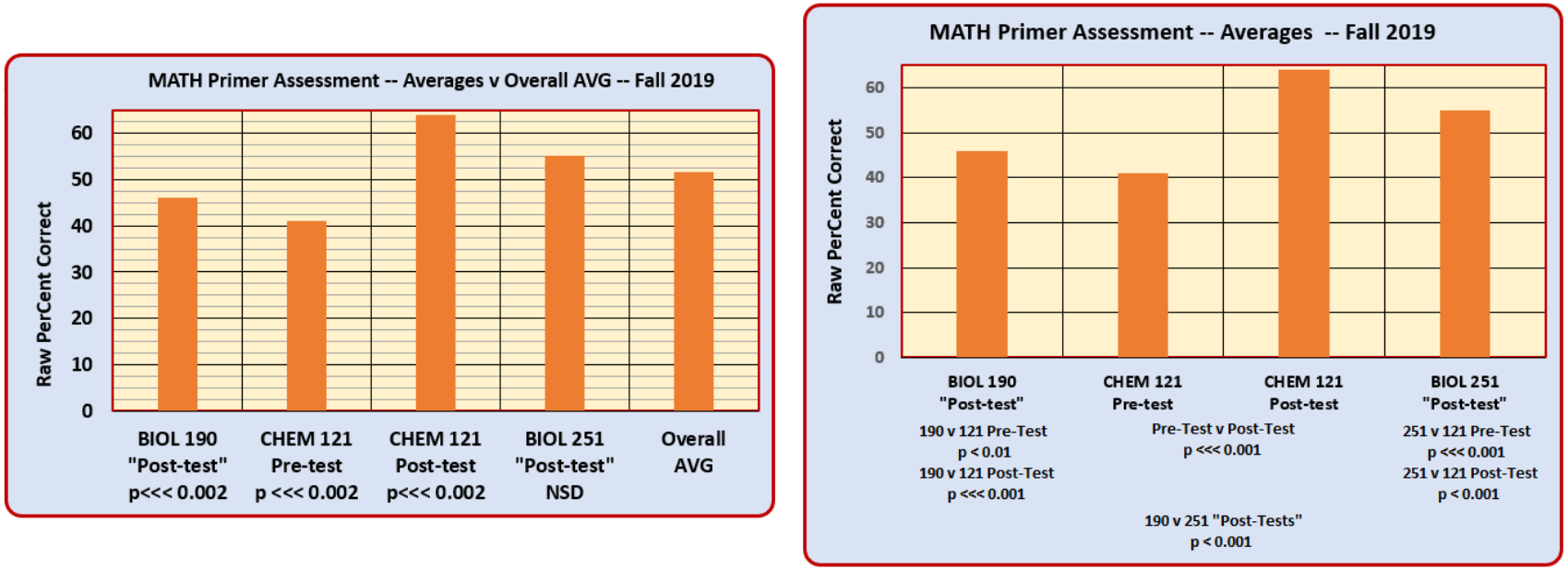

***Figure 1**. Assessment and statistical significance of MATH Primer Assessment results. Course averages v overall average, left; within and between group averages, right.*

Discussion

After reviewing the results in **Figure 1** above, it was clear that other information was needed in an attempt to comprehend the differences between the three courses' outcomes. The author obtains demographic and academic information from students pre- and/or post-course in an ongoing effort to explore where changes in support of student learning might be of assistance to students. This information is accumulated in Canvas. Of note, first, is the MATH course that students completed immediately prior to enrolling in BIOL 190 or CHEM 121 (comparable data, pre-course, is not being collected at this time; clearly it may be of interest in the future), **Figure 2**, below.

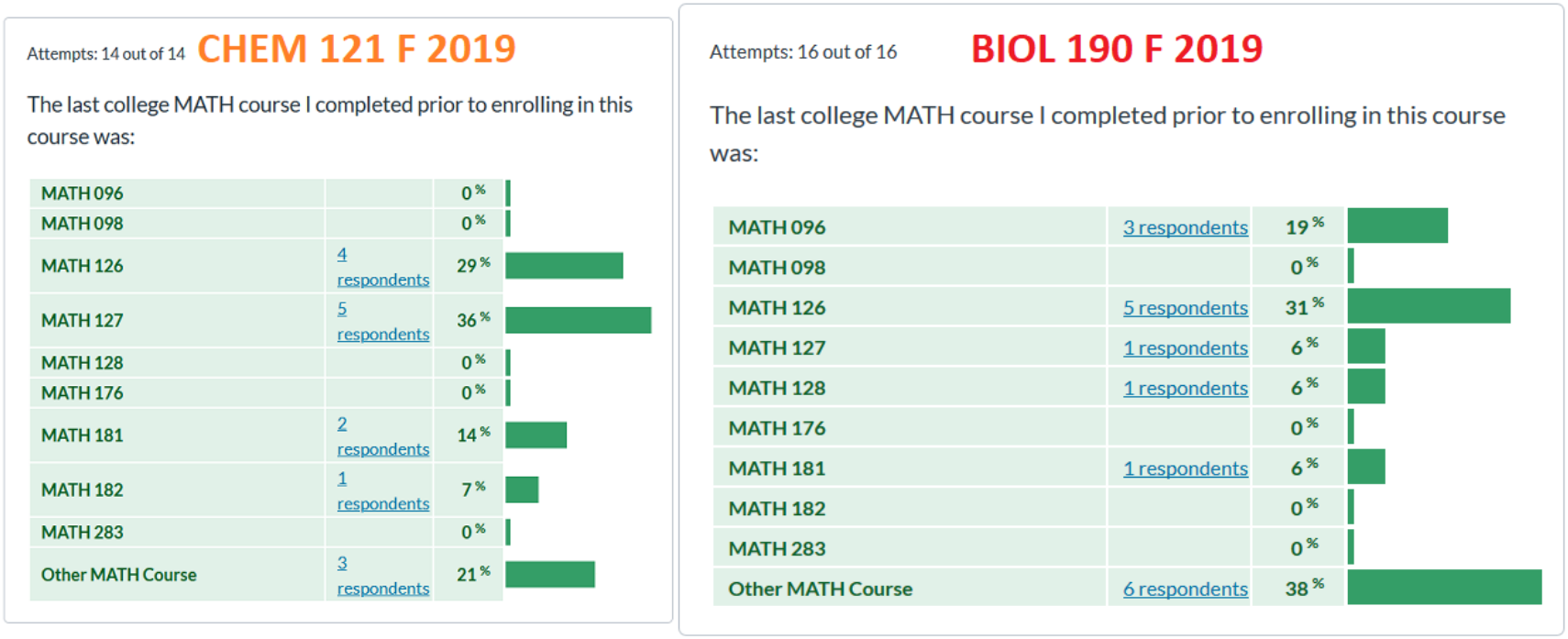

Figure 2. The last MATH course students completed prior to enrolling in CHEM 121 (left) or BIOL 190 (right).

As one can quickly observe, 86% of CHEM 121 students completed MATH 126 up to MATH 182, whereas only 49% of BIOL 190 students completed comparable courses. Right at a fifth of BIOL 190 students completed MATH 096. Approximately 40% of BIOL 190 students

completed some "Other MATH Course". It's not uncommon for students to take a course and not remember the course DEPT and number, hence, it's possible that one of WNC's MATH courses was actually taken and there may be a skew in the results. That said, however, the MATH Assessment results in BIOL 190 (and 251) coupled with the self-reported course (**Figure 2**) are certainly consistent with previous MATH pre-requisite findings [1].

In addition, students provided the final course grade that they received in the MATH course they completed just prior to enrolling in these courses, **Figure 3**, below:

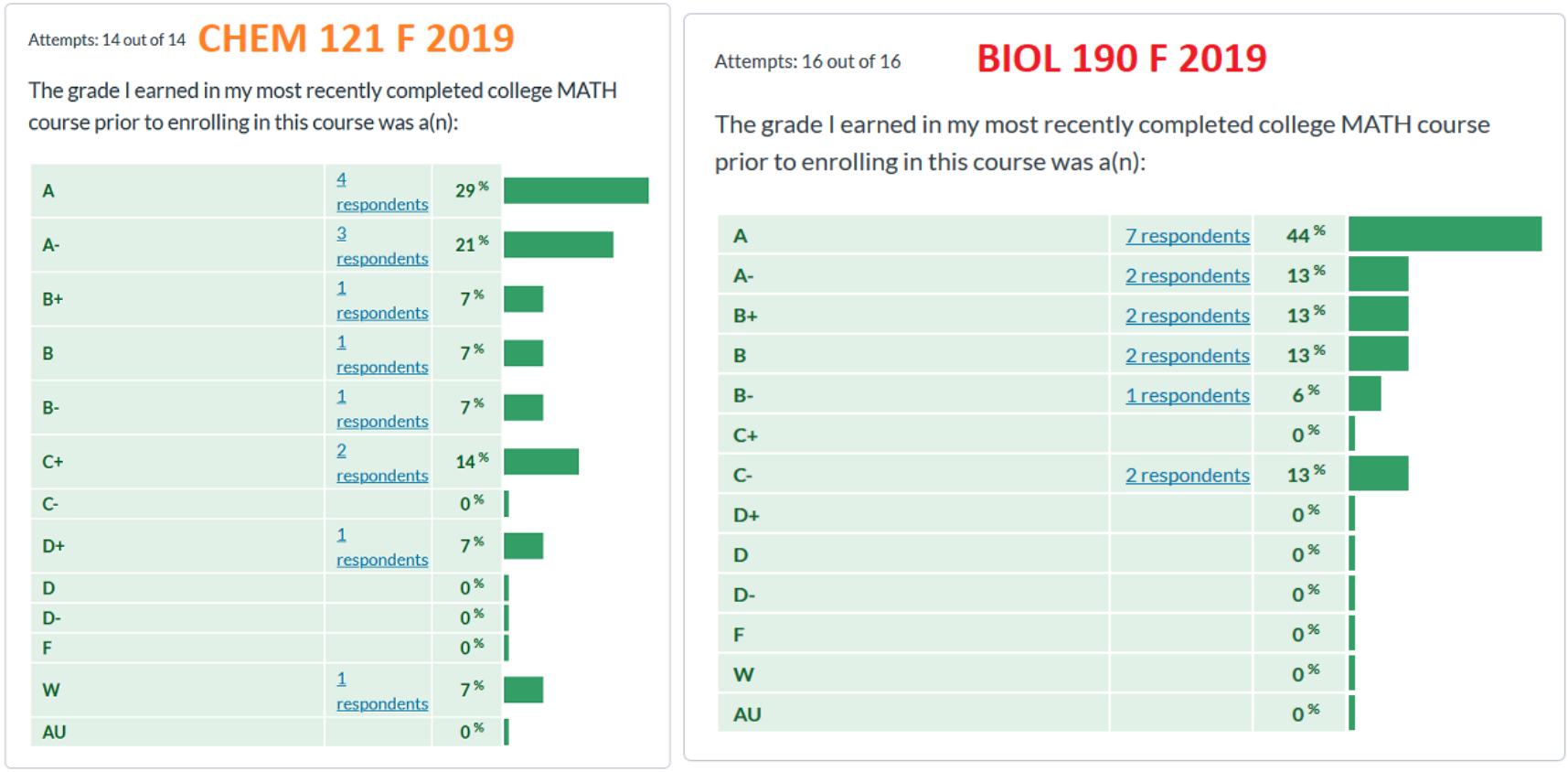

Figure 3. Student-reported final course grade in MATH class completed immediately prior to enrolling in CHEM 121 (left) or BIOL 190 (right). Average final MATH course grade for CHEM 121 = 3.0 (B) and for BIOL 190 = 3.61 (B+).

The final course grade averages (as listed in the caption to **Figure 3**, above) are confusing as the post- (and "post-") test results are non-congruent with the average final MATH course grades. Indeed, the average grades are "flipped". It's anticipated that once the new MATH pre-requisites are implemented for BIOL 190 that this "flip" will "auto-correct" itself.

For the time being, at least, it does seem to appear that CHEM 121 students are more "numbers oriented" than are BIOL 190 [/251] students. Given that WNC's NURS program requires a one (1) week intense MATH course on dosage calculations (in class) pre-first year NURS school and that UNR-Orvis requires a combination Medical Terminology/Dosage MATH 16-week course (online), it seems that the issue is more common than one might expect. (Note should be made that UNR-Orvis requires both CHEM 121 and BIOL 190 for the "pure" pre-BSN student, hence, one might erroneously intuit that those students have stronger MATH skills.)

To get a better feel for the students, their year in college (freshman, sophomore, etc.) was also collected, **Figure 4**:

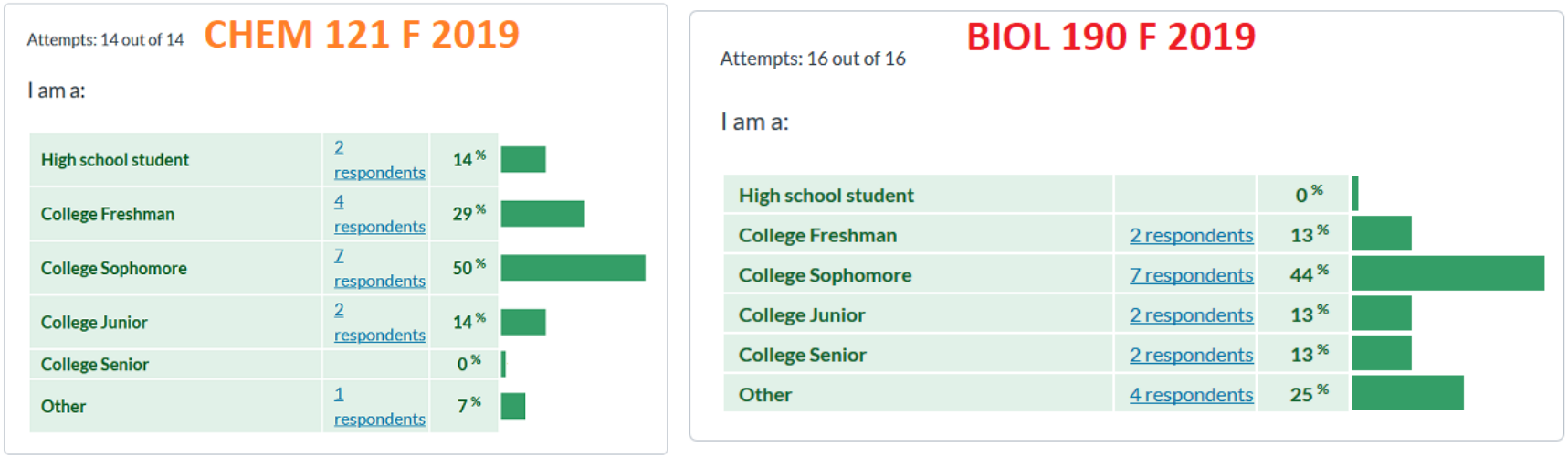

Figure 4. Student self-reported year in college.

43% of CHEM 121 students and 13% of BIOL 190 students are high school students or college freshman; 64% of CHEM 121 students and 70% of BIOL 190 students are college sophomores or more advanced. While the latter grouping isn't that different, the actual ages of the students were more telling, **Figure 5**, below.

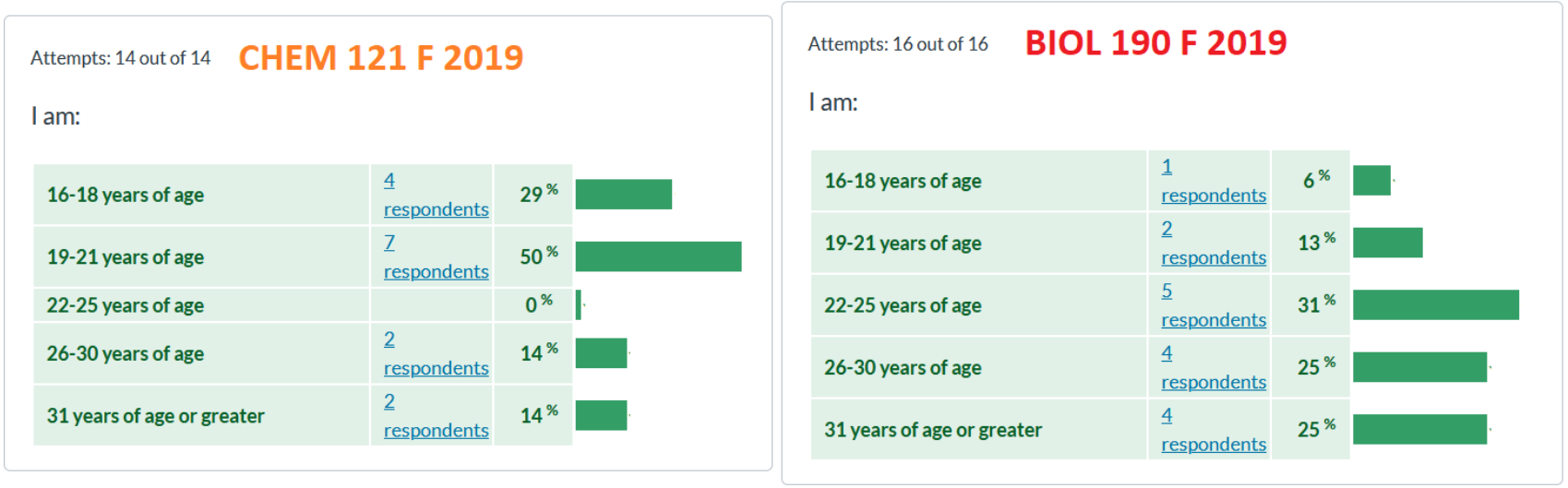

Figure 5. CHEM 121 and BIOL 190 students' demographic data by age group.

79% of CHEM 121 students are between 16 and 21 years of age; 81% of BIOL 190 students are 22 years of age or greater. While it's unlikely that student age has little to do with the MATH Primer Assessment outcome in this report, it's clear that there are two very different groups being served by the two courses, i.e., the younger, first time, student in CHEM 121 and the more mature returning student in BIOL 190. This is not inconsistent with more mature (more life experienced) students [re]turning to higher education to help them improve their lives, as well as their families' lives.

Returning to the MATH Primer Assessment, of interest is that **absolutely no questions** on Rules/Properties of Logarithms met inclusion criteria in the Assessment exams [3]. It was at this point that the author consulted electronically with Dr. Schwartz (see **Appendix 1**) regarding the match-up of textbooks on Openstax' website with WNC's MATH courses' content.

The Rules/Properties of Logarithms are clearly part and parcel of both MATH 096 and MATH 126 at WNC; in addition, the author not only lectured on the Rules/Properties of Logarithms during the first week of classes to address that short-fall, he also includes a section in the MATH Primer on the Rules of Log's. Openstax' textbooks describe three Rules/Properties of Log's; the MATH Primer adds a fourth Rule/Property: The Root Rule. While the Root Rule of Logarithms is a derivative of the Power Rule of Logarithms, it's of

substantial enough importance in CHEM 122 to begin prepping students in CHEM 121 to learn about it as a separate Rule/Property of Logarithms (See **Appendix 2**).

Of note is that the two Openstax texts support each other, i.e., the Intermediate Algebra (MATH 96) book introduces the logarithms in nice detail and the College Algebra (MATH 126) book takes advantage of that introduction and runs with logs.

While it is possible to argue that students in BIOL 190, BIOL 251 and CHEM 121 had "exam familiarity" with the MATH Primer Assessment, that argument falls apart as follows: BIOL 190 students had never seen the assessment before they completed their "post-test"; of the BIOL 251 students, 26% had never seen the Assessment (improvement in scores may have received a small impact from BIOL 190 attrition, however); given all the homework assigned in CHEM 121, it's unlikely that exam familiarity played a role in their clear assessment success. Were the familiarity to have played a role in their success, one would expect that CHEM 121 students would progressively improve on identically repeated homework assignments scheduled much closer together; experimentally, students tend to do no better or worse on those sorts of assignments.

Conclusions and Recommendation

While the Reading portion of this assessment (as described previously [1]) is still ongoing, it's clear in this small sampling of restricted students that CHEM 121 students are statistically more mathematically inclined than BIOL 190 and 251 students. It remains highly recommended that the minimum MATH pre-requisite for BIOL 190 be changed as previously requested/proposed [1].

Clearly, the two courses for which demographic information was obtained fill two niches at WNC: the younger student (CHEM 121) and the more mature, returning, student (BIOL 190). This is most likely by design, rather than default, inasmuch as BIOL 190 is the gold standard pre-requisite to BIOL 223 and 251 (both pre-NURS science courses).

There is non-congruency between students' self-reported final MATH course grades and their results from the MATH Primer Assessment. It's expected that this will auto-correct when the minimum MATH pre-requisite for BIOL 190 is changed as previously recommended/proposed.

Acknowledgements: Many grateful thanks to Dr. Gary Schwartz for his patient explanation of the course content of WNC MATH courses and comparing that to the Openstax MATH textbooks!

Appendix 1

MATH Topic Clarification: WNC Course vs Openstax Textbook

Personal e-Communication, Sep 5, 2019 at 12:04 PM

Dr. Gary Schwartz, WNC Professor of Mathematics

Here is the complete correspondence between our courses and the books I see on [O]*penstax, up to Precalculus:*

- *Pre-algebra was Math 93, which we no longer offer,*
- *Elementary Algebra is Math 95,*
- *Intermediate Algebra is Math 96,*
- *College Algebra is Math 126 (note: the book includes a chapter on Analytic Geometry (i.e., conic sections) that we don't cover in Math 126 - we put that material in Math 127),*
- *Trigonometry is Math 127. (There is no separate book for this, but the material is included in both the Algebra & Trigonometry and Precalculus books.)*

The "Algebra and Trigonometry" and "Precalculus" books would be for a two-semester sequence (Math 126+Math 127) or an accelerated, one-semester precalculus course (Math 128). In particular, both of these books include all the material in the College Algebra book. Math 127 would not be equivalent to any of [the] *books I see on* [O]*penstax. Here is a reasonable collection of chapters that would constitute a Trigonometry (Math 127) course:*

	Chapter	
Topics	***Algebra/Trig***	***Precalculus***
Angles & Trig functions	*7*	*5*
Graphs of trig functions, inverse trig functions	*8*	*6*
Trig equations & identities	*9*	*7*
Solving triangles, polar coordinates, vectors	*10*	*8*
Analytic geometry (conic sections)	*12*	*10*

Appendix 2

Screenshots of

Openstax Intermediate Algebra Properties of Logarithms;

Openstax College Algebra Rules of Logarithms;

Lecture Notes from Dr. Carman Root Property of Logarithms.

In the Order Cited, Below:

Intermediate Algebra (https://cnx.org/contents/AndhM9Sd@10.2:tGunCymg@15/10-4-Use-the-Properties-of-Logarithms) Accessed 1559 hours PST, 1 Dec 2019.

College Algebra (https://cnx.org/contents/mwjClAV_@15.1:nVZd13Io@16/6-5-Logarithmic-Properties), Accessed 1608 hours PST, 1 Dec 2019.

Carman (MATH Primer Lecture Free-Lance Lecture Second Day – CORRECTED)

PRODUCT PROPERTY OF LOGARITHMS

If $M > 0, N > 0, \mathrm{a} > 0$ and $\mathrm{a} \neq 1$, then,

$$\log_a (M \cdot N) = \log_a M + \log_a N$$

The logarithm of a product is the sum of the logarithms.

QUOTIENT PROPERTY OF LOGARITHMS

If $M > 0, N > 0, \mathrm{a} > 0$ and $\mathrm{a} \neq 1$, then,

$$\log_a \frac{M}{N} = \log_a M - \log_a N$$

The logarithm of a quotient is the difference of the logarithms.

POWER PROPERTY OF LOGARITHMS

If $M > 0$, $\mathrm{a} > 0$, $\mathrm{a} \neq 1$ and p is any real number then,

$$\log_a M^p = p \log_a M$$

The log of a number raised to a power as the product product of the power times the log of the number.

Intermediate Algebra -- Openstax

THE PRODUCT RULE FOR LOGARITHMS

The **product rule for logarithms** can be used to simplify a logarithm of a product by rewriting it as a sum of individual logarithms.

$$\log_b(MN) = \log_b(M) + \log_b(N) \text{ for } b > 0$$

THE QUOTIENT RULE FOR LOGARITHMS

The **quotient rule for logarithms** can be used to simplify a logarithm or a quotient by rewriting it as the difference of individual logarithms.

$$\log_b\left(\frac{M}{N}\right) = \log_b M - \log_b N$$

THE POWER RULE FOR LOGARITHMS

The **power rule for logarithms** can be used to simplify the logarithm of a power by rewriting it as the product of the exponent times the logarithm of the base.

$$\log_b\left(M^n\right) = n\log_b M$$

College Algebra -- Openstax

ROOT PROPERTY OF LOGARITHMS

If $\mathbf{x} > 0$, (knowing the base and $\neq 1$; 10 in this case) and $\mathbf{y}$ is any real number then,

$$\log \sqrt[y]{x} = \frac{\log x}{y}$$

$$\log x^{\frac{1}{y}} = \frac{1}{y} \log x = \frac{\log x}{y}$$

The log of the y'th root of a number, x, is the log of that number divided by the root value; this rule is a derivative of the **POWER PROPERTY OF LOGARITHMS**.

Carman -- MATH Primer Lecture Second Day Fall 2019